[*Liable to Revision.*]

APPENDIX A. TO THE GENERAL SCIENCE MINUTE, 2ND JUNE 1859.

THE following Syllabus has been prepared in order to afford candidates for certificates as teachers of Science, under the Science Minute of the 2nd June 1859, some guide to their reading; but it must be understood that the questions in the examination need not necessarily be on the specific points enumerated, but will be of as practical a nature as possible in the subjects of which the outlines are here indicated.

The examination will be both by paper and vivâ voce, and satisfactory evidence may be required of the teacher's power of giving information to a class. The subjects will be divided as shewn, the examination in each subdivision being distinct, so that candidates may, if they desire it, take a certificate only in a subdivision of a subject for which they will receive the portion of the augmentation grant shown in the Syllabus. Mention is made of text-books solely to afford a candidate some assistance in selection and a general idea of the scope of the examination, *and not at all to confine his reading to those works or to assert that they are the best on the subjects they treat of.*

No precise course of reading having been laid down, the examination papers will contain a large number of questions (arranged in sections of three questions each), with the view of affording a candidate full opportunity of showing any knowledge he may possess of a subject. The candidate will be allowed to try only one question in a section, as the three questions in a section will be as much as possible on the same part of a subject, though treating it in a different manner. The first question in each section will be the most elementary, the second more advanced, and the third more advanced still.

For the whole of the "No. 3" questions in a subdivision of a subject, 100 marks will be given; for the whole of "No. 2," 80 marks; and for the whole of "No. 1," 60 marks. A first-class certificate can only be gained by a candidate obtaining 80 marks at least; a second-clase certificate by obtaining 60 marks at least; a third-class certificate by obtaining 40 marks at least.

Any certificate obtained at the examination may be raised, by re-examination, in the next or any following November to a higher grade.

SYLLABUS.

SUBJECT I.

Practical Plane, and Descriptive Geometry, Mechanical and Machine Drawing, and Building Construction.

This subject will be taken under three subdivisions, viz.,—(first subdivision) Practical Plane, and Descriptive Geometry, for which half the certificate allowance will be granted. (Second subdivision) Mechanical and Machine Drawing, for which one-fourth the certificate allowance will be granted. (Third subdivision) Building Construction, for which one-fourth the certificate allowance will be granted, and it will be open to the candidate, to pass in either of the subdivisions alone or in all, but a teacher will not receive the certificate allowance for Subdivisions II. or III., until he has passed in I.

Subdivision I.—Practical Plane, and Descriptive Geometry.

Practical Geometry, plane and solid; required by architects, engineers, mechanists, shipbuilders, and others employed in arts of construction.

The candidate will be expected to have acquired readiness in the use of the usual drawing instruments and materials, to be skilful in drawing lines and circles in Indian ink, plain or dotted, of different degrees of fineness; drawing parallel equi-distant lines, at least six inches long, and from five to twenty or thirty in an inch; drawing from ten to thirty lines, passing through one point and forming equal angles; dividing by trial lines and arcs into any number of equal parts. He should also be able to mend his drawing pens and other instruments, and to verify his rulers, &c.

Constructions in Plane Geometry.

1. To draw lines through given points, in every position, either parallel, perpendicular to, or to form any proposed oblique angle, with given lines.

   The use and construction of the *protractor*, and of the "scale of chords" for these purposes, should be understood, and the deduction of certain angles from the direct division of the circle.

2. To draw circles or arcs, through given points, to touch given lines or circles, and, conversely, lines to touch circles.

   Required in drawing framework for machinery, architectural designs, ornamentation, &c.

3. The principles of drawing symmetrical forms by means of co-ordinates to the axis of symmetry.

   This is the basis of all drawing, of all objects of construction, which are universally symmetrical, not only in architecture, civil and naval, but in machinery and engineering works of all kinds.

4. Constructions of figures *similar* to given rectilinear or mixtilinear figures.

   Here the construction and use of "scales" plain and comparative, should be thoroughly understood and explained, also the principles of the *diagonal* and the *vernier* subdivision. Also the mode of reducing or enlarging drawings by means of similar rectangles, termed *squaring* a drawing. The use of the sector and of proportional compasses, and of the pentagraph and eidograph, in facilitating copying should be known.

5. To construct rectilinear figures similar to given ones, but with a proposed area.

6. To determine by construction numerical quantities such as $\sqrt{m}$; $\sqrt{\frac{1}{m}}$; $\sqrt{a^2 \pm b^2}$, &c.

7. To construct a triangle, any three parts being given.

Used in levelling, surveying, and the determination of heights and distances. Great accuracy, neatness, and distinctness of construction, will be insisted on: Geometrical drawing is valueless unless it possesses these requisites. A few illustrations of constructions on the ground, by means of a "chain," pins and cords, necessary in surveying, and "setting out" buildings and earthworks, may be added to the course, as well as the solution of a few elementary problems by means of the compasses alone.

8. The delineation of a few of the curve lines required in the arts, such as the ellipse, cycloidal curves, the involute and sinusoid, with the graphical method of determining their tangents and normals.

Required in designing elliptic arches, oblique bridges, teeth of wheels, cam-work, screws, &c.

9. Practice in tinting and shading with Indian ink, so as to express curved surfaces and shadows.

For the preceding part of the course, a fair knowledge of the first six books of Euclid is strongly enjoined, some acquaintance also with trigonometry will be of service, as without such previous knowledge, the learner is simply copying what is set before him, and cannot attain the highest skill in drawing.

Constructions in Solid Geometry.

(Descriptive Geometry.)

Preceded by explanations of the term *projection*, and of the necessity for it, in order to express graphically, on a surface, *solids* of any kind; the distinction between *orthographic and perspective projections;* their uses, and general principles which are the foundation of their practical application.

Orthographic Projection.

Why the projections, of any solid consisting of a combination of geometric forms, on two or three *co-ordinate planes* are necessary to show the form and dimensions of that solid.

Meaning of the terms *plan, elevation, profile, section.* The principle of the representation of *surfaces* by the projections of their generators, or of equi-distant horizontal sections termed *contours.* The direction and inclination of an indefinitely extended plane given by its contours, or by its *traces* on any two co-ordinate planes.

These principles should be quite familiar to the candidate, and will be tested by making him draw plans, elevations, and sections of simple solids, as prisms, pyramids, cones, spheres, cylinders, and of symmetrical solids formed by their combinations.

A few of the problems relating to points, lines, planes, and curved surfaces, will be required, as—

1. To draw lines and planes parallel or perpendicular to each other, to contain given points or lines, and the limits of the possibility of solution of any problem should always be understood.

2. The preceding constructions combined and applied to determine by their projections the simple solids before mentioned, when they are not symmetrically situated with respect to the supposed planes of projection.

3. Applications to the intersections of surfaces, and of the development of such as admit of it.

   This may be considered the most important part of descriptive geometry to the artizan, as it is required in all arts of construction. The mason, carpenter, and shipwright, workers in tin-plate, boiler makers, &c., would all be benefited by a knowledge of it.

   This application has been termed Stereotomy, and better and more significantly in French, "Coupe de pierres."

   Much practical knowledge of the subject, arising from their pursuits, is possessed by workmen, while the want of a scientific knowledge of it compels architects, engineers, and their drawing clerks to leave to the workmen the execution of their conceptions which they cannot themselves design.

4. The solution by construction of the spherical triangle from any three given parts, is mentioned.

   As important to masters, mates, and others engaged in any kind of astronomical calculations.

Isometric Projection.

Is usefully employed in the representation of works chiefly of a rectangular form, such as timber framing, canal-locks, and many parts of machinery; its use is much increasing: it is readily understood, and can be practised by anyone who has gone through the first two articles of this section.

Perspective Projection.

May be taken up, but will not be insisted on as it is rarely used except by architects to represent buildings (not yet executed), as they would appear to the eye at any spot from which they could be viewed, and the power of applying it for this purpose is possessed by many who know little of the really easier subject of descriptive geometry; but as its application by the architect must be subordinated to artistic taste, this consideration excludes it, in some measure, from a purely geometrical course.

No one, however, can be considered a scientific draughtsman unless he can apply perspective projection to the projection of shadows, the projections of the sphere, the constructions of maps and dials, and some other uses.

For the second division of this course, in addition to what was before indicated, a competent knowledge of the theorems relating to the line and plane (Euclid, Book XI.), and an acquaintance with the leading properties of the conic sections, the geometry of the sphere, and some spherical trigonometry is important, it cannot be too urgently recommended to all persons wishing to master this course, to study such works as "Geometry, Plane, Solid, and Spherical" of the Library of Useful Knowledge, and Mr. Bell's, in Chambers' Educational Course.

Subdivison II.—Mechanical and Machine Drawing.

The application of the foregoing Subdivision I. to the drawing of machinery, in which great accuracy and neatness of drawing will be insisted on.

The candidate will be required to take measurements with calipers, &c., and to make drawings, elevations, and sections of a simple machine, or of parts of one, set before him. Also to draw a portion of a machine from written dimensions and description. He will be required to have sufficient knowledge of the principles of machinery, gearing, &c., to be able to make working drawings of a machine or portions of a machine from a rough sketch, applying the power to the greatest advantage, and obtaining such power or changes of motion as are required. In fine, such knowledge and readiness as would be required of a good draughtsman in an engineer's office.

Subdivision III.—Building Construction, or Practical Architecture.

The candidate will be required to possess sufficient knowledge of construction—(1) to apply the various materials used in building to their greatest advantage; (2) to be able to make detail and working drawings showing a knowledge of the methods of construction and the framing of ordinary roofs, bridges, &c., whether of wood, iron, or masonry; (3) to frame estimates and take out quantities.

Neatness, accuracy, and facility in drawing will be insisted on, and the general requirements in this Subdivision will be such as would be possessed by a good draughtsman in an architect or builder's office, with a slight scientific knowledge for the proper application of the materials he is required to work with.

Text-Books for Practical Geometry.—Burchett's *Practical Geometry; Practical Geometry, Linear Perspective and Projection* (Library of Useful Knowledge). For Descriptive Geometry.—Hall's *Elements of Descriptive Geometry for Students in Engineering.*—Heather's *Descriptive Geometry.* Also the following French Works are mentioned, in consequence of the great deficiency of English Works on Geometrical Drawing.—*Elémens de Géométrie Descriptive*, par S. F. Lacroix; *Traité de Géométrie Descriptive,* par Levebure de Fourcy; *Nouveau Cours raisonné de Dessin Industriel,* par Armengaud, aîné, et Armengaud, jeune, et Amouroux; Bardin's Works on Descriptive Geometry. *Geometry, Plain, Solid, and Spherical* (Library of Useful Knowledge) is especially recommended as a work to be studied on Theoretical Geometry.

SUBJECT II.

Mechanical Physics.

This subject will be taken under two subdivisions, for each of which half of the certificate allowance will be granted.

Subdivision I.—Mechanics as a Science, or Theoretical Mechanics.

Statics. Composition and resolution of forces. Forces acting on a point, on a rigid body. Parallel forces. Centre of gravity. Theory of moments or couples. Principle of virtual velocities. The mechanical powers. Friction. Equilibrium of roofs and arches.

Dynamics. Laws of motion. Uniformly accelerated motion. Motion by gravity. Variable forces. Projectiles. Centrifugal force. Motion on inclined planes, on curves. Pendulums. Motion of rigid bodies, free or constrained. Moment of Inertia. Centre of oscillation, of percussion. Motion of flexible bodies, such as a musical string.

Hydrostatics, Hydrodynamics, and Pneumatics. Mechanical properties of liquids. Law of pressure. Centre of pressure. Laws of floating bodies. Capillary attraction. Laws of fluid motion, through open channels, closed pipes, or orifices.

Mechanical properties of elastic fluids. Theory of barometers. Connexion between pressure, temperature, and volume. Specific heat. Weight of atmosphere. Use of barometer in calculating heights.

In this division the candidate will have to show a mathematical knowledge of the laws of Mechanics, and must be able to prove from first principles the principal theorems.

The books recommended for study are—Whewell's *Elements of Mechanics,* or Snowball's; Moseley's *Engineering Architecture; Natural Philosophy,* by Dr. Golding Bird and Mr. Brooke; Goodwin's *Elementary Course.*

Subdivision II.—Mechanics as an Art, or Applied Mechanics.

General principles of mechanism. *Elementary combinations.* When the connexion is by rolling contact, sliding contract, wrapping connectors or linkwork, with constant or varying velocity ratio, and constant or varying directional relation.

Machines of ordinary occurrence must be thoroughly understood and particular parts to be described and drawn: such as cranes; lathes; drills; planing, punching, boring, shaping, and slotting machines. Spinning and weaving machinery. Mode of calculating power of machinery. Dynamometers, indicators, &c.

Materials. The general properties of materials. Elasticity. Weight. Specific weight. Mechanical work. Work done by pressure, by impact, by expansion of elastic gases and steam, by animal muscular effort.

Resistance to expansion, to compression, to rupture. Friction of solids. Its importance in construction. Resistance of fluids to bodies moving within them. Adaptation of form and material for maximum resistance. Beams of greatest strength. Construction of roofs, arches, stone and timber bridges, suspension bridges, and tubular girders.

Hydrostatics, Hydrodynamics, and Pneumatics. Pressure on flood-flates; locks; water-wheels; turbines; water-pressure engines; breakwaters. Hydrometers. The syphon. Hydraulic ram. Pumps. Diving bell. Condenser. Windmills. Steam-engines, stationary, marine, locomotive. The steam hammer. Water supply to towns. Theory of tides, in the open sea, and in rivers.

In this subdivision the candidate will be expected to show how the principles are applied in actual practice: he will be expected to show by clear well-drawn sketches, his acquaintance with parts of machines.

The candidate will have tools and models put before him, with some of which he must show he is familiar, and that he can explain their use and construction.

Books recommended,—Willis's *Mechanism;* Baker's *Elements of Mechanism;* the books in Weale's Series which treat on the subjects specified.

SUBJECT III.

Experimental Physics.

This subject will be taken under two subdivisions, for each of which half the certificate allowance will be granted.

Subdivision I.—Acoustics, Light, and Heat.

Acoustics.

The candidate ought to know the manner in which sound originates, and is propagated; its velocity in different media, and how its velocity through air is affected by density and temperature.

He ought to know the origin of musical sounds; of pitch; of harmony and discord; to commit to memory the rates of vibration of the several notes of the gamut; to be able to make sonorous vibrations visible by means of glass plates and membranes; to calculate the length of sonorous waves, and to determine practically the number of vibrations due to any particular note. He ought therefore to understand the construction and use of the Syren.

He ought to be able to describe and illustrate the condition of a vibrating string, or column of air at its nodal points and ventral segments, and to explain echos and resonance.

Light.

The candidate ought to know how its velocity was first determined from observations upon Jupiter's satellites.

He ought to be able to devise a simple means of exhibiting both the reflection and refraction of light; to be able to state the laws of both; to explain what is meant by total reflection; and to apply it to the explanation of the Mirage of the Desert, the Phantom Ship, and other similar phenomena.

He ought to be able to explain why the image in a plane mirror must appear as far behind the mirror as the object is in front of it; why a stick appears bent when dipped obliquely into water; and why the bottom of a river or lake, or of a basin which holds water, appears to be nearer to the surface than it really is.

He ought to be able to determine the positions of the foci of spherical mirrors, both concave and convex; to describe the characters of their images, whether erect or inverted; magnified or reduced; and to do the same for convergent and divergent lenses.

He ought to know the construction of the human eye; the conditions of distinct vision, the use of spectacles; and to be able to describe a simple form of the reflecting and refracting telescope and of the microscope.

He ought to know the constitution of light; to be able to describe the spectrum produced by refraction with a prism; to explain the origin of colours, and to give a clear explanation of the rainbow.

Heat.

The candidate ought to be able to describe the construction and graduation of an ordinary mercurial thermometer; to understand the scales of Fahrenheit, Celsius, and Reaumur.

He ought to have clear ideas of conduction and radiation; to be able to devise some simple means whereby the conductive and radiative powers of different bodies may be determined; to explain fully the formation of dew, and to state the conditions favourable to its production.

He ought to know the effect of heat upon the volumes of bodies; to know what is meant by the coefficient of expansion, and how it may be determined; to give illustrations of the enormous power of heat in producing expansion; to state exceptional cases; to know the manner in which heat is propagated through liquids and gases, as distinguished from ordinary conduction; and to be able to combine two metals possessing different coefficients of expansion, so as to form a compensating pendulum.

He ought to know the meaning of latent heat and of specific heat, and to illustrate both by reference to ice, water, and steam; he ought to be able to show the influence of the high specific heat of water upon an island climate.

He ought to know the strict physical meaning of ebullition; and the influence of pressure upon the boiling points of liquids; he ought to have a general knowledge of the origin of winds and clouds, and to be able to explain the fact that the rain-fall upon the south-west side of a mountain chain in England and Ireland is much more copious than on the north-east side.

Subdivision II.—Magnetism and Electricity.

Magnetism.

The candidate ought to know the action of one loadstone upon another which is freely suspended, or set afloat upon a liquid; he must have a perfectly clear notion of magnetic polarity, and of the action of magnetic poles upon each other.

He must know the difference between the action of magnetised and unmagnetised steel upon a magnetic needle; also the difference between soft iron and hard steel, with regard to their acceptance and retention of the magnetic condition; (coercive force).

He must be able clearly to state the condition of a mass of soft iron when under the influence of a magnet, and in virtue of which condition the iron is attracted; (magnetic induction).

He must be able to describe the action of the earth upon a magnetic needle; must know the meaning of declination, inclination or dip, and of secular and diurnal variation; the action of the earth upon a bar of soft iron according as it is held in the direction of the dip or at right angles to this direction; finally, the effect of percussion in rendering the condition assumed by the bar of soft iron a permanent one.

He ought to be able to compare accurately the strength of one magnet with that of another, and to state how the relative intensity of the earth's magnetism at two points of its surface may be ascertained.

Frictional Electricity.

The candidate ought to know various simple ways of exciting electricity; to be clearly informed as to the duplex character of the force; to know the condition of the rubber as well as that of the body rubbed; and to be conversant with various forms of electroscopes and electrometers.

He ought to know the foundation of the terms vitreous and resinous, positive and negative; to be able to illustrate the action of two electrified bodies upon each other; and to tell at once whether a body is positively or negatively charged.

He ought to have a clear knowledge of electric conduction, insulation, and induction; and be able to explain the state of a neutral conductor when acted upon by an electrified body; he ought to be able to prove, experimentally, that though we cannot by breaking a magnet obtain two halves each with a single pole, we can by breaking an electrified body obtain two halves each charged with a single electricity.

He ought to be able to explain the influence of points and flames when attached to an electrified conductor; and to describe the action of lightning conductors.

He ought to be able to describe the electric machine, and the electrophorus; and to explain the action of the condenser and of the Leyden jar.

He ought to be able to state the principal effects of the electric discharge; to state the atmospheric conditions necessary to the production of a thunderstorm; and to give a clear account of the so-called return stroke.

Voltaic Electricity.

The candidate ought to be able to state precisely how voltaic electricity may be generated; to describe Volta's pile, and his crown of cups; and also the batteries of Daniell, Grove, and Bunsen.

He must have a clear conception of what is meant by the direction of an electric current; and be able to illustrate in the fullest manner the action of a current upon a freely suspended magnetic needle. Given the direction of the current, he must be able to state how the needle moves; given the movement of the needle, he must be able to infer from it the direction of the current.

He must be able to describe fully the action of a current upon soft iron; and to infer from the direction of the current the nature and position of the magnetic poles, which it excites.

He must be well acquainted with the chemical reactions which take place both in the batteries, mentioned above, and also in other liquids through which the current may be sent.

He must be able to measure the strength of an electric current, and he is strongly recommended to master thoroughly the law of Ohm, regarding the mutual relations of electromotive force, resistance, and strength of current.

He ought to be acquainted with the so-called polarisation of metallic plates between which a current passes through a liquid, and to show how this is avoided in Grove's battery.

He ought to be able to give a clear description of some one form of the electric telegraph.

He ought to be acquainted with the physiological effects, and with those of light and heat produced by the voltaic current; and to show the dependence of the heat on the strength of the current, and on the resistance which it encounters.

It would also be well to master as much of the phenomena of induced currents as would enable the candidate to explain the action of the galvanizing apparatus used by medical men.

NOTE.—The candidate will perceive that this list is long because the objects to which he is to devote his attention are separately specified. Definition is thus given to his studies and their precise scope marked out for him. He is recommended to repeat with his own hands, as far as it is in his power to do so, the experiments which he finds described in good handbooks of Natural Philosophy; this will give a certainty to his knowledge and an interest to his pursuits which mere reading can never confer. The first requisite demanded of him on his examination will be that, however small his knowledge, it shall be well digested and sound.

Text-Books:—Lardner's *Handbook of Natural Philosophy; Natural Philosophy*, by Dr. Golding Bird and Mr. Brooke.

SUBJECT IV.

CHEMISTRY, INORGANIC AND ORGANIC.

This subject will be taken under two subdivisions, for each of which half the certificate allowance will be granted.

Subdivision I.—Inorganic Chemistry.

The general principles of chemical philosophy. Laws of combination. Combining weights and chemical equivalents. Combining volumes. Chemical symbols and their use in the explanation of chemical changes. The atomic theory.

The non-metallic elements: *Oxygen.* Combustion.

Hydrogen. Water. Chemical composition and properties. Adaptation for domestic purposes. Hardness, permanent and temporary.

Nitrogen. Nitrous oxide, nitric oxide. Nitric acid. Nitrification. Ammonia.

Carbon. Process of carbonization. Carbonic oxide. Carbonic acid. Marsh gas. Olefiant gas. Manufacture of coal gas.

Sulphur. Sulphurous acid, sulphuric acid. Sulphuretted hydrogen. Bisulphide of carbon.

Chlorine. Hypochlorous acid. Bleaching agents and theory of bleaching. Chloric acid and perchloric acid. Chloride of nitrogen. Chlorides of carbon.

Bromine. Bromic acid and hydrobromic acid.

Iodine. Iodic acid, periodic acid, and hydriodic acid.

Fluorine. Hydrofluoric acid.

Phosphorus. Hypophosphorous acid, phosphorous acid. The several modifications of phosphoric acid: ordinary phosphoric, pyrophosphoric, and metaphosphoric acids. Theory of polybasic acids. Phosphoretted hydrogen. Chlorides of phosphorus. Manufacture of matches.

Boron and boracic acid.

Silicium and silicic acid.

The metals: *Potassium.* Manufacture of nitre. Manufacture of gunpowder. Theory of the action of gunpowder. *Sodium.* Manufacture of carbonate of soda.

Barium. Strontium. Calcium. Mortars.

Magnesium, Aluminium. Manufacture of glass and porcelain.

Manganese. Iron. Composition and properties of cast iron, wrought iron and steel.

Cobalt. Nickel. Chromium. Zinc. Cadmium. Copper. Lead. Manufacture of white lead.
Bismuth. Mercury. Tin. Arsenic. Course of analysis in cases of poisoning.
Antimony. Silver. Gold, and *platinum.* Their principal compounds with the non-metallic elements.
Outline of qualitative analysis. Reactions of the principal mineral acids and bases. Course pursued in the application of these reactions to the analysis of a mixture of several acids and bases.

Subdivision II.—Organic Chemistry.

Ultimate analysis of organic bodies. Calculation of an empirical formula. Methods of controlling an empirical formula. Determination of the equivalents of organic acids and bases, examination of products of decomposition, determination of the vapour-density of volatile bodies. Law of substitution.
The chemical history of the Cyanogen group. Cyanogen. Hydrocyanic acid. Cyanic acid and urea. Fulminates. Cyanuric acid. Sulphocyanic acid. Chlorides of cyanogen.
Amylaceous and saccharine substances. Fermentation. Alcohol, and its homologues. Ethers, simple and mixed. Oxidation of alcohol. Aldehyde and acetic acid, and their homologues. Anhydrides, simple and mixed. Compound ethers. Diatomic alcohols and their acids. Glycol and oxalic acid. Triatomic alcohols. Glycerine. Fatty and oily bodies.
Ammonia and its derivatives. Amides and amines: their classification. Examples of natural alkaloids.
Principal colouring matters. Indigo and its derivatives. Examples of products formed by destructive distillation.
The chief constituents of the vegetable and animal organism, fibrin, albumen, casein, &c.
The chemical principles of agriculture.
The chemical principles of the process of nutrition and respiration in the animal organism.
Text-books. — Graham's *Elements of Chemistry,* Miller's *System of Chemistry,* Fownes' *Manual of Chemistry,* Gregory's *Outlines of Chemistry,* Abel and Bloxam's *Handbook of Chemistry,* Galloway's *Qualitative Analysis.*

SUBJECT V.

Geology and Mineralogy.

This subject will be taken under two subdivisions, for each of which half the certificate allowance will be granted.

Subdivision I.—Geology.

1. The division of rocks into three great classes, aqueous, igneous, and metamorphic.
2. The mode of formation of stratified rocks,—marine strata—delta formations—freshwater beds,—the sign by which you can distinguish these.
3. The mode of occurrence of igneous rocks, ashes, lavas, and dykes.
4. Volcanoes and volcanic phenomena.
5. The theory of central heat.
6. Elevation and depression of land.

7. The ordinary mineral substances that enter into the composition of rocks.
8. Fossilization of organic bodies.
9. Table of geological formations, including those larger divisions absent in Britain.
10. Theory of metamorphism of rocks.

British Strata.

1. Description of the Cambrian strata and Silurian strata, their lithological characters, disturbances and chief fossils.
2. Description of the old red sandstone and Devonian rocks, character and fossils. Origin of cleavage. Slate and slate quarries, building-stones, limestones, and marbles.
3. The carboniferous limestone and coal measures. Character, fossils, and mode of formation. Origin of the coal of the coal-measures, and its mode of occurrence. Mode of occurrence of the ironstone of the coal measures. Various kinds of coal, and the relation of anthracite coal to disturbance of strata. Lime quarries, marbles, and building stones. Clay pits and potteries of the carboniferous strata. Fire clay. Alum shale.
4. The Permian rocks. Their strategraphical relations to the underlying strata, composition of rocks, fossils, and building-stones.
5. The new red sandstone (or Trias), its subdivisions, fossils, building-stones, sand pits, rock salt, and brine springs.
6. The Lias. Its subdivisions, chief fossils, building-stones, and other hydraulic limestones, and clay pits.
7. Oolitic rocks. Subdivisions, leading fossils, building-stones. Limestones. Clay pits, and other economic products.
8. The Purbeck and Wealden strata. Origin, subdivisions, chief fossils, building-stones, and marbles. Ironstones and limestones. Clay pits.
9. Cretaceous rocks. Subdivisions, lithological characters, fossils, building stone of lower greensand. Gault, its phosphatic nodules and general uses. Upper greensand, chalk, &c. Building stones. Origin and uses of chalk-flints.
10. Eocene, or older Tertiary beds. Subdivisions, alternation of marine and freshwater beds, chief fossils, limestones and building stones, clays for bricks and potteries.
11. Crag. Its subdivisions, chief fossils, phosphatic remains.
12. Disturbance and denudation of strata.
13. Unconformities, faults, and fractures.
14. The causes of gaps in the succession of strata, or of breaks in the succession of life in time.
15. Water-bearing strata, and underground drainage. Artesian and other wells.
16. British rocks in which ores of metal are found, and the general mode of occurrence of these ores in beds or lodes.
17. The rules that ought to guide the miner in sinking for coal and other minerals, when the beds in which they lie are concealed by over-lying and unconformable strata.
18. The occurence of stream tin, gold, &c., in superficial detritus.
19. The chief differences in the nature and mode of occurrence of various formations in areas widely seperated from each other.

Text-books.—Lyell's *Principles of Geology;* Lyell's *Elements of Geology,* Phillips' *Manual of Geology;* Jukes' *Manual of Geology;* Page's *Introductory Text-Book;* Page's *Advanced Text-Book.*

Subdivision II.—Mineralogy and Mining.

A. Instruction in this subject should commence with a distinct understanding of the characters by which minerals, properly so called, are to be distinguished from other inorganic substances, and of the position of this science in relation to the collateral sciences of physics, chemistry, and geology.

B. Crystallography, as the essential means of appreciating the forms naturally assumed by almost all inorganic bodies, must commence with the needful geometrical definitions, proceed to the grouping of the various crystalline forms into systems, consider the laws by which the derivation of one form from another within the limits of the same system is determined, and explain the combination of various simple forms in the faces exhibited by compound crystals. It is also important to study the deviations from regularity which are commonly presented in nature, and the methods of measuring those elements which remain constant.

C. The various kinds of aggregation exhibited by crystalline substances is also to be considered, especially with reference to masses of the useful minerals, and of crystalline rocks.

D. Next in order will follow the physical characters of minerals; 1st, in relation to their substance, as cleavage, fracture, hardness, and specific gravity: 2ndly, in relation to the effects of light, as transparency, refraction, lustre, and colour; 3rdly, as to their elastic and magnetic properties.

E. The chemical characters of minerals, and the most convenient modes of testing them; 1st, by aid of the blowpipe; 2ndly, by the moist way.

F. Pseudomorphism, or the remarkable phenomena presented by minerals which have the composition of one mineral coupled with the form of another.

G. The physiography or systematic description of minerals. This last division should include all the more remarkable varieties as well as species, and should take especial note of the modes and places of occurrence, as well as of the association of particular groups of minerals in certain veins or formations.

As text-books may be recommended—

Professor Ansted's *Elementary Course of Mineralogy and Geology*. London, 1856.

Nicol's *Elements of Mineralogy*. Edinburgh, 1858.

Dana's *Manual of Mineralogy*.

For more advanced students—

Brooke and Miller's *Mineralogy*. London, Longman, 1852.

On Crystallography. Rev. W. Mitchell in Orr's "Circle of the Sciences." London, 1856.

Dana's *System of Mineralogy*. 4th edition. Putnam, 1854.

Naumann's *Mineralogie*. Leipzig.

Breithaupt's *Paragenesis der Mineralien*. Freiburg, 1849.

Haidingen's *Handbuch der Mineralogie*. Vienna.

As it is intended to teach this subject with special reference to the practical working of minerals, the physiographical part will be occupied more particularly with certain of the useful species and their associated substances, and the following works may be consulted.

W. J. Henwood *on the Metalliferous deposits of Cornwall and Devon*, 1843.

Bischof *on Chemical and Physical Geology*, translated by the Cavendish Society, 1854.

SUBJECT V.

Natural History.

This subject will be taken under two subdivisions, for each of which half the certificate allowance will be granted.

The field presented hy Natural History is such an exceedingly wide one, that candidates are advised to confine their studies to the subjects enumerated below, and to master these as thoroughly as possible. And as in the Natural Sciences, the knowledge which is obtainable by mere reading is of very little value, candidates are particularly recommended to study nature for themselves, and to become personally acquainted with the primary facts of Biological Science. Thus in Physiology, the fundamental truths relating to circulation, muscular contraction, and nervous action, may all be readily exemplified by simple experiments upon the common frog; and in Systematic Zoology and Botany, the careful study of the structure of the animal and vegetable forms enumerated under the head of "types" will furnish a better conception of the animal and vegetable worlds than any amount of mere reading. Candidates will therefore be expected to be thoroughly and practically acquainted with all the most important and distinctive characteristics of such of these typical genera as are illustrated by British species.

Subdivision I.—Zoology and Physiology.

1. Candidates should have carefully studied what is stated upon the subjects enumerated below in any good handbook of Physiology.

The qualitative chemical constitution of animal bodies. The nature of food. The processes of digestion and assimilation. The qualitative composition and offices of the blood. Circulation of the blood; its object and the means by which it is effected. Secretion and the qualitative composition of secretions. The waste of the organism and the mode of elimination of waste products. Cutaneous and renal excretions. Respiration; its purpose, and the mechanism by which it is effected. Animal motion, and the instruments by which it is effected. Cilia, muscles, bones. The rudiments of animal mechanics. Nervous matter as an originator of motion; its general structure and composition.

Sensation and thought. The organs of the senses. The spinal cord and the brain, and their offices. Reflex action. Instinct. Habit, and the conversion of voluntary into instinctive actions.

Reproduction and multiplication. Reproduction of lost or injured parts. The healing of wounds. The process of sexual reproduction. The hereditary transmission of peculiarities, and the effect of the condition of parents on offspring.

The elements of Hygiene, and the nature of the principal kinds of disease. Inflammation. Contagious diseases. Scrofula. Cancer.

2. Candidates should have carefully mastered the definitions of the *sub-kingdoms*, *classes*, and *orders* of the Animal Kingdom. They should understand and be able to explain the meaning of the terms employed in such definitions; and they should be able to refer any specimens that may be placed before them to their proper *classes.*

3. Candidates should be able to give fair answers to questions relating to any or all of the following subjects, and they should be able to identify, refer to their proper orders, and if called upon to do so, describe, the objects enumerated in each section under the head of "types." In almost all cases these "types" are British animals.

By the term Natural History, of such and such an object, is meant such an account of it as is to be found in any standard modern work on Zoology.

i. The structure and inode of multiplication of infusorial animalcules and *Foraminifera*. The arguments which have been adduced for and against spontaneous generation. The luminosity of the sea, and the nature of the creatures which chiefly cause it. The natural history of the sponge of commerce. Types—***Spongia, Vorticella.***

ii. The meaning of the terms, zoophyte, coral, coralline. Natural history of the red coral of commerce. Common coral and coral reefs. What such reefs are, where they are formed, and how they grow. Natural history of the common freshwater polype, or hydra, and of the "jelly fishes," or "medusæ" of the sea. Asexual multiplication as exhibited by these creatures. Types—***Hydra, Sertularia Plumularia, Actinia, Corallium, Fungia, Oculina.***

iii. Starfishes, sea urchins, and *Holothuriæ;* their structure and habits, and the metamorphoses which they undergo. Natural and economical history of Trepang. Types—***Uraster, Echinus.***

iv. Natural history of the earthworm and the leech. Intestinal worms; their structure, propagation, and mode of entrance into animal bodies. Natural history of the ***Rotifera.*** Types—***Lumbricus, Hirudo, Distoma, Tænia, Ascaris.***

v. Natural history of ***Crustacea.*** The lobster and crayfish, as exemplifying morphological and teleogical laws. The process of ecdysis. Barnacles, acorn shells, and fish lice, as cases of extreme metamorphosis. The water flea as exemplifying asexual multiplication. Types—***Cancer, Homarus, Astacus, Oniscus, Daphnia, Cyclops, Lepas, Balanus, Argulus.***

vi. Natural history of spiders, scorpions, and mites. The "itch insect," centipedes, and millipedes. Types—***Tegenaria, Scorpio, Scolopendra, Julus.***

vii. Insects; their mode of breathing as contrasted with that of spiders and crustaceans. The structure of their wings, and the mechanism of flight. The parts of the mouth and their modifications in beetles, bees, butterflies, bugs and gnats. Structure of the eyes. Nature of stings, saws, and ovipositors. Natural and economic history of the blistering beetle, of the silk moth, of the bee, of the cochineal insect. Natural history of plant lice, of bugs, fleas, and lice. The house fly, blow fly, and gnat, wasps, humble bee, ichneumon flies, "black beetles," crickets, and locusts. The metamorphoses of insects. Types—***Melolontha, Blatta, Libellula, Phryganea, Coccus, Aphis, Bombyx, Apis, Vespa, Musca.***

viii. The characteristic peculiarities of the nervous, circulatory, respiratory, and locomotive organs of molluscs in general. Organization of "sea mat" (***Flustra***). Ascidians and "lamp shells" (***Terebratula***). Natural history of fresh-water and marine mussels. Nature of mother of pearl. Formation of pearls. Pearl fishery. Natural and economical history of the oyster. Organization of snails and slugs, periwinkles, limpets, whelks. Development of the young of the latter. Nidamental capsules. Cuttlefishes and squids. Paper nautilus. Pearly nautilus. The shipworm and pholas. Mechanism by which molluscs bore. Types—***Flustra, Ascidia, Terebratula, Unio, Mytilus, Ostrea, Pecten, Helix, Patella, Littorina, Buccinum, Chiton, Sepia, Loligo, Argonauta, Nautilus.***

ix. Circulatory, respiratory, and reproductive organs of fishes. Their dentition. Natural and economical history of the lamprey, sprat, sardine, herring, pilchard, salmon, trout, eel, cod, haddock, sole, flounder, turbot, mackerel, tunny, sturgeon, skate, ray, dog

fish, shark. Electrical fishes. Fishes which are capable of living in air. Pisciculture, or the artificial breeding of fishes. Types—*Amphioxus, Petromyzon, Syngnathus, Cyprinus, Perca, Accipenser, Lepidosteus, Raia, Spinax.*

x. Natural history of salamanders, newts, frogs, and toads. Metamorphoses undergone by their young. Types—*Salamandra, Triton, Rana.*

xi. Circulatory and respiratory organs of reptiles as distinguished from those of fishes and amphibia. Natural history of snakes, lizards, crocodiles, turtles, and tortoises. Tortoise-shell. Shedding of the skin in reptiles. Types—*Coluber, Pelias, Anguis, Lacerta, Crocodilus, Testudo, Chelone.*

xii. Organs of locomotion, respiration, voice, circulation and reproduction of birds. Structure and mode of growth of feathers. Development of the fowl's egg. Artificial hatching. Migrations and instincts of birds. Natural history of domestic birds; of the ostrich, the apteryx, the penguin, and the dodo. Types—*Falco, Corvus, Columba, Picus, Phasianus, Ardea, Struthio, Anser.*

xiii. Organs of respiration, circulation, and reproduction of mammals. Production and nutrition of their young. Placental and implacental mammals. Nature of milk and of the lacteal glands. Peculiarities in the dentition of mammals. Natural and economic history of the domestic mammals; of the ivory and fur yielding mammals; of seals; of whales. The hybernation and migration of mammals. Characters of the orders of mammals. Types—*Cercopithecus, Vespertilio, Erinaceus, Lepus, Elephas, Sus, Cervus, Bos, Agnus, Felis, Phoca, Phocæna, Dasypus, Halmaturus, Ornithorhynchus.*

xiv. The distinctive peculiarities of man. The characters of the principal races of mankind, and their geographical distribution.

Text-books for Physiology.—Carpenter's *Animal Physiology*, Bohn, 1859; Andrew Combe's *Physiology applied to Health and Education.* For Zoology.—Dallas's *Natural History of Animals;* Orr's *Circle of the Sciences;* Gosse's *Manual of Marine Zoology;* Professor Greene's *Manual of the Protozoa.*

Subdivision II.—Botany.

Vegetable Physiology.

In this department the candidate will be expected to answer correctly questions on the following points:—

1. The properties of the principal elements entering into the composition of plants. Carbon, oxygen, hydrogen, nitrogen, sulphur, phospherous, chlorine, iodine, silicon, potassium, sodium, calcium, iron.
2. The composition and properties of the compounds forming the principal part of the structure of plants. Cellulose, starch, dextrine, sugar, fixed oil, gluten, albumen, caseine. The saline compounds forming the ashes of plants.
3. The composition and properties of vegetable secretions used in the arts. Colouring matters. Chlorophyle. Gum. Resin. Caoutchouc. Gutta Pertsha. Volatile oils. Acids,—Citric, Malic, Tartaric, Oxalic. Alkaloids and neutral principles,—Theine, Morphine, Strychnine, Aconitine, Conine.
4. The origin and growth of the vegetable cell. The tissues of plants. Cellular tissue. Intercellular organs. Epidermal tissue. Hairs. Cotton. Stomates. Cork. Vascular tissue. Woody tissue. Fibres of linen, hemp, and others used in weaving.

5. The structure and functions of the organs of plants. The root. Spongioles. Absorbtion and excretion. Nature of vegetable food. The stem. Structure of Exogenous, Endogenous, and Acrogenous stems. The leaf. The forms of leaves. Exhalation. Stipules and bracts. The flower. Calycine, Corollal, Staminal, and Carpellary leaves. Development and nature of pollen. Ovules or seed buds. Vegetable impregnation. Embryo. Seed. Fruits; their nature and forms. The nature of the reproductive organs in flowerless plants.

Systematic Botany.

In this department the candidate will be expected to demonstrate the structure of plants from living specimens.

1. The distinctions between the three great classes of plants, Dicotyledons, Monocotyledons, and Acotyledons. Also of the groups Gymnosperms, Rhizanths, Dictyogens, Acrogens, and Thallogens.
2. The characters of the following orders of British plants should be mastered, and the typical genera recognized, and their structure understood.
3. *Algæ.* The natural history and uses of sea-weeds. The microscopic structure of diatoms and desmids. Nature of the reproductive organs in this order. Types—*Navicula, Desmidium, Conferva, Fucus, Ceramium.*
4. *Lichens.* The natural history and uses of lichens. Structure of their reproductive organs. Types—*Graphis, Collema, Parmelia.*
5. *Fungi.* The natural history of mushrooms, puff-balls, moulds, blights, and toadstools. Their uses in nature. Types—*Agaricus, Bovista, Torula, Aspergillus, Morchella, Mucor.*
6. *Mosses.* The nature of their reproductive organs. Types—*Bryum, Sphagnum, Funaria.*
7. *Ferns.* Nature of their rhizomes. Herbaceous and tree ferns. History of development, and nature of reproductive organs. Types—*Polypodium, Hymenophyllum, Osmunda.*
8. *Graminaceæ.* The history of grasses and their uses. Nature of the flower in this order. Useful plants of the order. Types—*Phleum, Hydrochloa, Panicum, Agrostis, Arundo, Spartina, Avena, Festuca, Hordeum, Triticum, Secale, Nardus, Anatherum.*
9. *Cyperaceæ.* Sedges. Types—*Carex, Scirpus.*
10. *Liliaceæ.* The lily tribe, its useful properties. Types—*Tulipa, Ornithogalum, Muscari.*
11. *Amaryllidaceæ.* The family of the narcissus, snow-drop, snow-flake. Types—*Narcissus, Galanthus.*
12. *Orchidaceæ.* The orchis family. Structure of reproductive organs. Types—*Orchis, Goodyera, Malaxis, Cypripedium.*
13. *Amentaceæ.* The family of the hazel, chestnut, oak, willow, birch, beech, poplar, and hornbeam. The uses of these plants as timber, &c. Types—*Quercus, Corylus, Fagus, Castanea, Betula, Myrica, Salix, Populus.*
14. *Urticaceæ.* The nettle and hop tribe. Its relations to *Moraceæ, Artocarpaceæ, Cannabinaceæ,* and *Ulmaceæ.* The nature of the stings of *Urtica,* and the bitter principle of the hop. Types—*Urtica, Parietaria, Humulus.*
15. *Euphorbiaceæ.* The spurge family. Foreign forms and their uses. *Croton, Cascarilla, Ricinus, Janipha.* Apetalous and Polypetalous forms. Types—*Euphorbia, Buxus.*
16. *Polygonaceæ.* The buckwheat and rhubarb tribe. Types—*Polygonum, Rumex.*

17. *Primulaceæ.* The primrose family. Theory of the peculiar position of stamens. Types—*Primula, Lysimachia.*
18. *Labiatæ.* The dead nettle tribe. Peculiar properties of this order. Types—*Mentha, Salvia, Thymus, Nepeta, Lamium, Teucrium.*
19. *Scrophulariaceæ.* The scrophularia tribe. Nature of the poisonous properties of the order. Types—*Scrophularia, Digitalis, Verbascum, Euphrasia, Veronica, Melampyrum.*
20. *Boraginaceæ.* The borage tribe. Peculiarities of their epidermis. Useful species. Types—*Cynoglossum, Borago, Echium, Myosotis, Lithospermum.*
21. *Solanaceæ.* The tribe of deadly nightshade, henbane, tobacco, and potato. Useful and poisonous species. Types—*Solanum, Atropa, Hyoscyamus, Datura.*
22. *Ericaceæ.* The heath tribe. Its distinction from *Epacridaceæ.* Types—*Erica, Arbutus, Vaccinium, Pyrola, Monotropa.*
23. *Compositæ.* The composite family. The number of species and geographical distribution. Structure of the sub-orders *Asteraceæ, Cichoraceæ,* and *Cynaraceæ.* Types—*Tussilago, Aster, Inula, Gnaphalium, Bellis, Artemisia, Achillea, Carlina, Carduus, Cichorium, Leontodon, Lactuca, Crepis.*
24. *Stellatæ.* The Stellate tribe. Its relation to *Cinchonaceæ* and *Caprifoliaceæ.* The properties and useful plants of Cinchonaceæ. Types—*Galium, Rubia.*
25. *Umbelliferæ.* Umbel bearing plants. Character of inflorescence and flowers. Nature of fruit. Structure of cremocarp. Properties of the order. Types—*Hydrocotyle, Sanicula, Eryngium, Apium, Sium, Æthusa, Œnanthe, Crithmum, Angelica, Pastinaca, Daucus, Torilis, Scandix, Conium, Coriandrum.*
26. *Cucurbitaceæ.* Melon, cucumber, and gourd family. Useful plants of this order. Type—*Bryonia.*
27. *Rosaceæ.* The rose, apple, cherry, and plum tribe. Forms of the fruit. The useful plants of this order. Types—*Prunus, Spiræa, Fragaria, Rubus, Geum, Rosa, Cratægus, Pyrus.*
28. *Leguminosæ.* The bean, pea, and clover family. Principal divisions of the family. Structure of the flowers and fruits. Useful plants of the order. Types—*Ulex, Trifolium, Vicia, Astragalus, Ornithopus.*
29. *Cruciferæ.* Cabbage, turnip, and mustard tribe. Structure of the flowers and fruits. Useful plants of the order. Properties. Types—*Nasturtium, Alliaria, Brassica, Sinapis, Armoracia, Iberis, Isatis, Crambe, Cakile.*
30. *Papaveraceæ.* The poppy tribe. Properties and mode of collecting opium. Nature of fruit. Types—*Papaver, Glaucium, Chelidonium.*
31. *Ranunculaceæ.* The crow-foot tribe. Structure of abnormal genera; *Aconitum, Aquilegia,* and *Delphinium.* Nature of poison in order. Types—*Ranunculus, Clematis, Helleborus, Pæonia, Anemone.*

Text-books for Vegetable Physiology.—Henfrey's *Elementary Course of Botany;* Van Voorst. Carpenter's *Vegetable Physiology,* edited by Dr. Lankester; Bohn. Schleiden's *Principles of Scientific Botany;* Bohn. For Systematic Botany.—Lindley's *Vegetable Kingdom.* For British Botany.—Bentham's *Handbook of the British Flora,* or Babington's *Manual of British Botany.*

STATEMENT of the RESULTS of the EXAMINATION of CANDIDATES for TEACHERS' CERTIFICATES in SCIENCE, held in November and December 1859, under the Minute of the Committee of Council on Education of the 2nd June 1859.

Subject I.—PRACTICAL PLANE, AND DESCRIPTIVE GEOMETRY, MECHANICAL AND MACHINE DRAWING, AND BUILDING CONSTRUCTION.

Subdivision I.—*Practical Plane, and Descriptive Geometry.*

THOMAS BRADLEY, Esq.

Nine Candidates, all of whom failed.

Subdivision II.—*Mechanical and Machine Drawing.*

Name.	Address.
2nd Grade Certificate.	
Hudson, Washington .	Eagle Foundry, Hunt Street, Manchester.
Four failed.	

Subdivision III.—*Building Construction, or Practical Architecture.*

Name.	Address.
2nd Grade Certificate.	
Hudson, Washington .	Eagle Foundry, Hunt Street, Manchester.
3rd Grade Certificate.	
Goodwin, William H. .	Marquis of Salisbury's school, Hatfield.
Four failed.	

Subject II.—PHYSICS, MECHANICAL AND EXPERIMENTAL.

Subdivision I.—*Mechanical Physics.*

Rev. B. M. COWIE, M.A.

Name.	Address.
2nd Grade Certificate.	
Seaman, Isaac . .	18, Cumming Street, Pentonville.
Simpson, Bentham .	St. Matthew's school, Bethnal Green.
3rd Grade Certificate.	
Hough, Joseph . .	Mechanics' Institute, Leeds.
Jeffery, Walter . .	Blue Coat Hospital, Gloucester.
Atkins, Edward . .	St. Martin's school, Leicester.
Pullen, Moses . .	National school, Painswick, Stroud.
Nelson, Robert J. .	Navigation school, Mercer's Street, Shadwell.
Five failed.	

Subdivision II.—*Experimental Physics.*

Professor TYNDALL, F.R.S.

Name.	Address.
1st Grade Certificate.	
Jeffery, Walter . .	Blue Coat Hospital, Gloucester.
2nd Grade Certificate.	
Simpson, Bentham .	St. Matthew's School, Bethnal Green.
Bartley, George C T. .	1, Rectory Place, Stoke Newington.
3rd Grade Certificate.	
Kerby, Isaac . .	St. Mary's school, Putney.
Atkins, Edward . .	St. Martin's school, Leicester.
Six failed.	

Subject III.—CHEMISTRY, INORGANIC AND ORGANIC.

Subdivision I.—*Inorganic Chemistry.*

Dr. HOFMANN, F.R.S.

Name.	Address.
1st Grade Certificate.	
Wood, Charles Henry .	Pharmaceutical Society, 17, Bloomsbury Square.
Barret, E. . . .	31, Gloucester Street, Regent's Park.
Jarmain, George . .	National school, Almondbury, Huddersfield.
Noble, John . .	Range Bank, Halifax.
2nd Grade Certificate.	
Hudson, Fearnside .	68, Corporation street, Manchester.
Levers, George . .	Wesleyan Training College, Westminster.
Longbottom, Josiah .	Wesleyan Training College, Westminster.
Holt, George . .	Wesleyan Training College, Westminster.
Northey, John . .	15, Salisbury Street, Lisson Grove.
Robertson, John . .	Messrs. Chances' school, Oldbury.
Waite, John . .	Wesleyan Training College, Westminster.
3rd Grade Certificate.	
Perry, George William .	St. Michael's school, Pimlico.
Martin, William . .	Woodhill school, Hatfield.
Rushforth, Thomas .	St. Thomas' school, Woolwich.
Clark, Albert Charles	National school, Salisbury.
Jeffery, Walter . .	Blue Coat Hospital, Gloucester.
Wheeler, George Henry	National school, Middleton, Manchester.
Greenstreet, William A.	Christ Church school, Chelsea.
Day, Thomas N. . .	Parochial school, Quaker Street, Spitalfields.
Ward, Thomas . .	Wesleyan school, Cheetham Hill, Manchester.
Mayer, John . .	Carlton Place school, Glasgow.
Hurst, William . .	Knighton Street school, Leicester.
Kitchen, William .	Wesleyan Training College, Westminster.
Bartley, George C. T. .	1, Rectory Place, Stoke Newington.

Name.	Address.
Blackwell, Charles A.	St. Mark's College, Chelsea.
Hancock, John	17, Riding House Street, Langham Place.
Jones, Thomas	St. Mark's school, Kemp Town, Brighton.
Packer, Matthew W.	37, Lincoln Street, Mile End.
Phillips, Harvey	5, Harrison Street, Gray's Inn Road.
Sheaf, Robert	South Stoneham and Portswood National School, Highfield, near Southampton.
Seven failed.	

Subdivision II.—*Organic Chemistry.*

Dr. Hofmann, F.R.S.

Name.	Address.
1st Grade Certificate.	
Wood, Charles H.	Pharmaceutical Society, 17, Bloomsbury Square.
Barret, E.	31. Gloucester Street, Regent's Park.
Jarmain, George	National school, Almondbury, Huddersfield.
Holt, George	Wesleyan Training College, Westminster.
Hudson, Fearnside	68, Corporation Street, Manchester.
2nd Grade Certificate.	
Mayer, John	Carlton Place school, Glasgow.
Northey, John	15, Salisbury Street, Lisson Grove.
Day, Thomas N.	Parochial school, Quaker Street, Spitalfields.
Robertson, John	Messrs. Chances' school, Oldbury.
3rd Grade Certificate.	
Jeffery, Walter	Blue Coat Hospital, Gloucester.
Ward, Thomas	Wesleyan school, Cheetham Hill, Manchester.
Coles, Ferdinand	5, Montpelier Terrace, Brompton.
Four failed.	

Subject IV.—Geology and Mineralogy (*applied to Mining*).

Subdivision I.—*Geology.*

Professor A. C. Ramsay, F.R.S.

Name.	Address.
1st Grade Certificate.	
Judd, John W.	Wesleyan Training College, Westminster.
2nd Grade Certificate.	
Simpson, Bentham	St. Matthew's school, Bethnal Green.
One failed.	

Subdivision II.—*Mineralogy.*

Professor WARINGTON SMYTH, M.A., F.R.S.

Name.	Address.
1st Grade Certificate.	
Judd, John W. . .	Wesleyan Training College, Westminster.
One failed.	

Subject V.—NATURAL HISTORY.

Subdivision I.—*Zoology and Physiology.*

Professor HUXLEY, F.R.S.

One Candidate, who failed.

Subdivision II.—*Botany.*

Dr. EDWIN LANKESTER, F.R.S.

Name.	Address.
1st Grade Certificate.	
Cooke, Mordecai R. .	Trinity schools, Lambeth.
One failed.	

PAPERS given to CANDIDATES in the EXAMINATION for SCIENCE CERTIFICATES, held at South Kensington, November 1859.

Except where otherwise specified, three hours were allowed for each paper.

Each candidate was also separately examined *vivâ voce.*

DIRECTIONS GIVEN OUT WITH THE PAPERS IN SUBJECT I.

Write your name legibly on the top left-hand corner of each sheet of drawing paper you use.

Write the number of the section and the number of the question which you attempt, above the solution, thus—Sec. VII. Ques. 2.

You are not permitted to attempt more than one question in each section.

It is not necessary that you should have answered a question in each section to obtain a certificate; the Examiner will take into consideration, according to the questions you answer, what might fairly have been done in the time allowed; therefore, do not attempt by bad drawing to hurry on the question. The number of sections is given solely to afford you a greater choice of subjects.

EXAMINATIONS FOR CERTIFICATES IN SCIENCE.

SUBJECT I.

Subdivision I.—PRACTICAL PLANE, AND DESCRIPTIVE GEOMETRY.

Examiner, THOMAS BRADLEY, Esq.

PLANE GEOMETRY.

One attendance (3 hours) was allowed for this paper.

The constructions for solving the following questions may be left in pencil, provided they are accurate, distinct, and explained by appropriate notation of lines, letters, and figures; but no written explanation, nor solution by calculation only, is admissible. But any candidate is at liberty to put his lines in ink if it is convenient to him to do so. No construction left incomplete or carelessly drawn will be considered.

SECTION I.

Divide a line 2·5 inches long—

1. Into two segments in the ratio 9 : 17.
2. Into two segments so that the rectangle under the whole line, and the less may be equal to the square on the greater segment.
3. Into two segments so that the squares on them may be in the ratio 7 : 5.

SECTION II.

Two lines are 2 and 3·5 inches long.

1. Find a third proportional to them.
2. Find a mean proportional to them.
3. Find an harmonic mean to them.

SECTION III.

If $a = 1{\cdot}3$; $b = 2$; $c = 3{\cdot}5$ find a line.

1. $d = \dfrac{b\,c}{a}$
2. $d = \sqrt{\{a^2 + b^2 - c^2\}}$
3. $d = \dfrac{a \pm \sqrt{(4b^2 + a^2)}}{2}$

SECTION IV.

The sides of a triangle are 3; 2·6; 2 inches.

1. Determine the inscribed and circumscribed circles.
2. Determine an equilateral triangle equal to it in area.
3. Determine a rectangle equal to it in area, but having its sides in the ratio of 3 : 2.

SECTION V.

1. Draw a square of 4·5 inches area.
2. Draw an equilateral triangle of the same area.
3. Draw a regular pentagon of the same area.

SECTION VI.

The distance between the centres of two circles is 3 inches, one of them is ·8, the other 1·5 inches radius.

1. Draw a circle of 1·3 inches radius to touch both.
2. Draw a circle of 3·25 inches radius to touch both, but to include both within it.
3. Draw a circle of 3·25 inches radius, to touch both, but to include the smaller, and to have the larger outside of it.

SECTION VII.

1. Draw an ellipse having its axis 3·75 and 2 inches.
2. Construct a tangent to this ellipse at any point of it not being the extremities of the axes.
3. Draw two conjugate diameters of this ellipse to contain an angle of 115°.

SECTION VIII.

1. Draw the curve (cycloid) traced by a point in the circumference of a circle of 1·25 inches radius, rolling along a straight line.
2. Draw the curve (epicycloid) traced by a point of the same circle when it rolls round another circle of 2·5 inches radius.
3. Draw the curve (involute) traced by one end of a flexible line, unwound from the circumference of a circle of 1 inch radius. (The whole curve need not be shown.)

SECTION IX.

1. Construct a scale to show feet and inches, when 7·5 feet are represented by a line 2·7 inches long.
2. Construct a scale of $\frac{1}{84}$ to show feet and inches by diagonal division.
3. Construct a scale of $\frac{1}{7040}$ to show furlongs and poles.

ORTHOGRAPHIC PROJECTION.

One attendance (4 hours) was allowed for this paper as far as Section IX. inclusive. The remaining sections were given out with the "Perspective" paper, and $3\frac{1}{2}$ hours allowed.

N.B.—In the following questions the word *inclination* always means inclination to the horizon or horizontal plane.

Section I.

1. The *plan* of a line is 2 inches long, the line itself is 3 inches: what is its inclination?
2. Two indefinite lines at right angles are inclined at 20° and 40°; represent them by a *plan* and *elevation*.
3. The *plans* of two such lines contain an angle of 35°; one is inclined at 30°; determine the inclination of the other.

Section II.

1. Two indefinite lines contain an angle of 60°; one is horizontal, the other is inclined at 30°: represent them by a *plan* and *elevation*.
2. Two parallel lines 3 inches long, and 2 inches apart are inclined at 38°; the line that would join their ends is perpendicular to both; the end of one is ·5, that of the other 2 inches above the plane of projection (the paper). Represent these lines in plan and elevation.
3. Two indefinite lines leaning in opposite directions are inclined at 30° and 60°; they are two inches apart where they approach each other the nearest: represent these lines by plan and elevation.

N.B.—The word *traces* means the line or lines in which a plane, or any other surface, cuts the plane or planes of projection.

Section III.

1. Represent by its *traces* an indefinitely extended plane inclined at 40°.
2. Represent by their *traces* two such planes, one inclined at 40° the other at 60°, and show their mutual intersection.
3. Represent the same two planes on the supposition that their intersection is inclined at 30°.

Section IV.

1. Represent a line and a plane that are perpendicular.
2. Represent two planes that are perpendicular, neither of them being vertical.
3. Represent three indefinite planes by their traces, each being perpendicular to the other two, and neither being vertical.

Section V.

1. The intersection of two planes is inclined at 35°; one plane is inclined at 50°, the other at 70°: determine the angle contained by these planes.
2. A plane inclined at 50° contains a line inclined at 35°; a second plane contains the same line, and makes an angle with the first of 60°: represent this line and planes.
3. Determine a third plane also containing the same line, but bisecting the angle made by the two former planes.

Section VI.

Represent by plan and elevation a square of 2 inches side.

1. When its plane is inclined at 30°, and one side at 20°.
2. When two of its sides are inclined at 20° and 30°.
3. When three of its corners are at 1 ; 2 ; 2·5 inches from the plane of projection (or paper).

Section VII.

Represent by plan and elevation a cube of 2 inches edge.

1. When one edge is horizontal, and one face inclined at 70°.
2. When no edge is horizontal and one face inclined at 30°.
3. When two of its edges are inclined at 20° and 30°.

Section VIII.

1. When the plane of one face is inclined at 30° and one edge inclined at 20°.
2. When two of its faces are inclined at 50° and 70°.
3. When two of its diagonals are inclined at 20° and 30°.

Section IX.

Represent by plan and elevation a pyramid 4 inches high with an hexagonal base of 1 inch side.

1. When it stands on the horizontal plane with no side of the base parallel to the vertical one.
2. When it stands on a plane inclined at 25° and a diameter of the base horizontal.
3. When standing on the same plane the diameter of a base is inclined at 20°.

Section X.

1. When one face is horizontal.
2. When one edge is vertical.
3. When the axis and one edge are equally inclined in a vertical plane.

Section XI.

1. A cylinder of 1 inch radius and 5 inches long is cut into two equal frustra by a plane inclined to the axis at 60° : *develope* one of them.
2. Two such cylinders have their axes at right angles, but that of one touches the surface of the other cylinder : develop the curve of intersection.
3. A right cone 4 inches high with a circular base of 1 inch radius is penetrated by a cylinder of ·75 inch radius, the axes intersecting at right angles in a point at 2·75 inches from the apex of the cone : develope the conical surface with the curve of penetration.

Section XII.

A sphere of 1 inch radius rests on the horizontal plane : determine the outline of its shadow on that plane.

1. When the sun's altitude is 65°.
2. When the luminary is a point, 6 inches from the centre of the sphere, and the line through it and the centre is inclined at 65°.
3. When the ray through the highest point of the sphere is horizontal.

Section XIII.

1. The *sides* a, b, c, of a spherical triangle are 28°, 38°, 50° : determine by construction the *angles* A, B, C.
2. Given $a = 28°$, $b = 38°$, and the angle $C = 50°$: determine A, B, and c.
3. Given $b = 38°$, $c = 50°$, and $B = 45°$: find a, A, C.

PERSPECTIVE PROJECTION.

This paper, which Candidates are not compelled to take up (see Syllabus) was given out with Sections X. XI. XII. XIII. of Orthographic Projection ($3\frac{1}{2}$ hours allowed).

The distance of the eye (" vertex of projection ") from the plane of the picture (" plane of projection ") is 8 inches; the intersection of an original plane with the picture to be 4 inches from the centre of the picture.

Section I.

The object being a square of 1·5 inches side, draw its projection as lying in the original plane.

1. When the plane of the square is perpendicular to that of the picture, one side of the square making an angle of 30° with the intersecting line, and one corner touching it.
2. When the plane of the square makes an angle of 80° with that of the picture.
3. Draw three such squares in a row, one of them being partly between the eye and the picture.

Section II.

1. Draw a cube, the square of the preceding section being one face of it.
2. Draw the same cube, the face being inclined at 80° as the square in (2).
3. Draw the three cubes having the squares of (3) for their faces.

Section III.

1. Draw a cylinder 6 inches long and 3 inches diameter, standing on a horizontal plane and touching the picture.
2. Draw the same cylinder when lying on its side; its axis making an angle of 60° with the plane of the picture.
3. Draw the same cylinder, but when the plane on which it lies is inclined 80° to the picture.

Section IV.

A prism 4 inches long with an hexagonal base of 1 inch side.

1. Draw it as lying on one face on a horizontal plane, its edges making an angle of 60° with the plane of the picture.
2. Draw it under the same conditions, but as if resting on one edge only, and its face inclined at 40° to the horizontal plane.
3. Draw it under the same conditions as last, but when the plane on which it lies is inclined at 50 to the plane of the picture.

SUBJECT I.

Subdivision II.—Mechanical and Machine Drawing.

Examiner, T. Bradley, Esq.

MECHANICAL AND MACHINE DRAWING.

This Paper was given out one afternoon (4 hours attendance), and again the next day (8 hours). During the Second day Candidates were permitted to go into the Patent Museum, if they wished it, to see the Machinery.

Unless when otherwise directed, it is not required that the drawings made by candidates in this subdivision should show details, such as teeth of wheels, threads of screws, bolts, &c., but they must clearly indicate the action of any moving parts of the machine, the direction of the

motion being shown by arrows: the parts of any mechanism which would not be seen are nevertheless to be represented by dotted lines, even if the drawing is left in pencil. Considerable latitude is given as regards these conditions, as well as to the scale on which the drawings are made, but the knowledge and skill of the draughtsman will be estimated by his ability in making the principle and action of the machine clear in the drawing, without written description beyond brief references, and neatness and accuracy in drawing is essential.

Section I.

1. Show by a geometrical diagram only, how the "parallel motion" of a beam engine produces an alternating rectilinear motion in the piston rod from an alternating circular one of the beam.
2. Show how the same effect is produced in a marine engine where the beam is below the cylinder.
3. Show in the same manner, how the continuous motion of the fly-wheel produces an alternating motion of the slide valves in stationary engines.

Section II.

1. Show by an outline the principle of the common "Governor."
2. Represent in outline this governor, when the change of velocity of rotation has altered the position of the "throttle valve."
3. Show, in addition to the above outline of it, how the governor is made to give a warning when the furnace requires attention.

Section III.

1. Show, in detailed section, a spherical valve to close an 1·5 inch pipe, with the cage by which it is kept from leaving its seat too far.
2. Show the combination of two such valves as employed in the force-pump of a locomotive for supplying the boiler.
3. Show a similar combination of clack-valves annexed to the hot water pump of a stationary engine.

Section IV.

1. Show by a detailed section, the steam-pipe, ports and eduction, with the slide valves of a locomotive.
2. Show the same for a stationary condensing engine.
3. Show the balanced slide valves with the cylinder of an engine, with the piston and stuffing box; the cylinder being 50 inches diameter with a 5 feet stroke, and acting expansively.

Section V.

1. Show how a different velocity in a shaft or axle is obtained from a constant velocity of the strap from the drum.
2. Show how in a common foot lathe the relative velocity from the treadle to the mandril is changed by means of a catgut band.
3. Show how a gradual alternating change in the velocity of the *follower*, is, in some cases, produced from a constant angular velocity of the *driver* by means of spur wheels.

Section VI.

Show in outline, without detail, an arrangement for producin gan alternating rectilinear motion from a continuous circular one.

1. As applied to the common mangle.
2. To move the tool of a slotting machine.
3. To move the table of a planing machine, or rolling steam printing press.

Section VII.

1. Show in detail how the jointing of a crank and rod is effected by means of a jib and cotter.
2. Shew a coupling for a shaft where the velocity is not great.
3. Draw a pillow or plumber-block for a shaft 4 inches diameter.

Section VIII.

1. Draw in detail an escape wheel (to carry on its arbor a seconds' hand) with a dead-beat anchor escapement, the pendulum vibrating seconds through an arc of 5°.
2. Draw in detail either the duplex, the horizontal, or the lever escapement of a watch.
3. Draw in detail the arrangement for maintaining the action of the mainspring while the chronometer is being wound up.

SUBJECT I.

Subdivision III.—Building Construction.

Examiner, T. Bradley, Esq.

BUILDING CONSTRUCTION.

One day (7 hours) allowed for the Paper.

The same general conditions as regards the drawings made in this subdivision to be observed as were given for the two former, but the different materials to be indicated by colours; as lake for brickwork, yellow for timber, indian ink for stone, and blue for iron.

A very substantially built warehouse 110 feet long, 43 feet broad, with a basement story 7 feet high, and 4 stories above ground each 9 feet high in the clear, the warehouse to be divided into two by a cross party wall 40 feet from one end; the whole basement story to be covered with groined arches on square brick piers, the ground floor to be paved with stone, laid on concrete on the back of the groining.

The upper floors of the larger divisions to be of girders carried on cast iron columns with bridging and flooring joists, and elm flooring boards, provision being made by trimming for a cast iron winding staircase to rise the whole height of the building; the roof to be a queen post roof with tie-beams, principals, etc., to allow a centre garret lighted by skylights in the roof, which is to be slated: there are to be two small rooms partitioned off on the ground floor, each with a fireplace, one for an office, the other as dwelling room for a porter.

The smaller division of the warehouse to be built fire-proof throughout the floors to be of sheet iron plates laid on cast iron frames supported on the flanges of iron beams, resting on iron columns: the roof to be of iron, open to the upper story, one iron door in a stone frame in each story, to be the only communication between the divisions; two windows with iron frames in stone in the front and back wall of each story of this part.

The larger division to have also two windows with wooden sashes and frames set in reveals, and a door in each upper story in the front wall next the street, with a drawbridge platform for landing goods from carts, the door to be closed by the platform when raised. An iron swing crane on stone corbel at the upper door.

Section I.

Prepare the following drawings to represent the above warehouse.

1. A plan of the basement story with the piers for the groined arches.
2. A plan of the ground floor with the two dwelling rooms.
3. A complete cross section to show the walls, floors, roof, etc., with the party wall.

Section II.

1. A plan of the timber of one floor with a section. (The flooring joists need be shown only in one compartment.)
2. A plan of the beams, frames, etc., of the iron floor, with detailed sections to show the constructions.
3. The timber truss for the roof, with plan and sections to show the framing.

Section III.

1. The elevation of the front next street.
2. A longitudinal section from end to end showing the windows, &c., in the back wall.
3. A drawing for the spiral staircase with detached detail figures to show the connexions of the several castings.

Section IV.

1. A working drawing of the entrance door, showing its frame, cill, its pannelling.
2. A drawing of one of the iron window frames and sashes.
3. A drawing of the wooden sash and frame for the office, showing the frame, boxings, shutters, etc.

Section V.

1. A section of the blocking course, gutters, and beams, wall plates, and framing of principals into the tie-beams, &c.
2. A drawing to show one of the cast-iron pillars to carry the floor, to show how it carries the girder, and is also bolted by stirrups to the cap of the pillar in the story beneath, also the section of the iron girders, their mode of carrying the frames, &c.
3. A drawing of one door, with drawbridge platform, showing the mode of raising and lowering it, its construction, and how it is to fit into the frame partly to close the door when raised, the rest being shut in by a flap shutter.

Section VI.

1. Write out a specification for the brickwork throughout.
2. Write out a specification for the timber and joiners' work.
3. Write out a specification for the stone and iron work.

N.B.—Each candidate to make his drawings and specifications accord as far as they go.

Section VII.

1. Draw a timber truss for a foot bridge of 30 feet span, with a cross section of the bridge.
2. Draw a timber truss for a partition of 30 feet span to have two doors in it, and to be independent of support by the floor beneath.
3. Design the centering for an elliptic stone arch of 60 feet span, and 18 feet rise, showing the mode of striking it gradually by withdrawing wedges.

Section VIII.

1. Show two or three modes of scarfing timber beams of long bearing.
2. Show how you would strengthen such a beam by an iron truss without cutting into the beam.
3. Show by the plans, of two courses at least of each, the bonding of brick walls from one brick to three bricks thick.

Section IX.

1. Show by a section and part elevation the construction of a wharf wall built on piles, faced with granite, with retaining counterforts, with timber fender piles to keep off vessels.
2. Show the framing for an octagonal wooden spire, 35 feet high, to be raised on a church tower 12 feet square.
3. A chimney 130 feet high to stand detached, to have four openings into it below ground, with occasional courses of masonry, a granite coping, and provision for a lightning conductor.

SUBJECT II.—PHYSICS.

Subdivision I.—Mechanical Physics.*

Examiner, The Rev. B. M. Cowie, M.A.

1st Paper.

Section I.

1. Enumerate the "Mechanical Powers." In each case give the relation between P. and W.
2. Prove the relation between P. and W. in the wedge with friction. Give instances of the employment of the wedge as a mechanical (statical) power.
3. Within a space of 9 cubic fest, some *mechanical* arrangement is to be fixed, by which a force of 5 lbs. shall be able to overcome a resistance of 30 tons. How would you propose to effect this?

Section II.

1. What is a *catenary?* Mention its principal properties.
2. Explain the mechanical principles involved in the construction of an arch.
3. Calculate the tension of the tie beam in a common ridged roof. How is it modified by the introduction of the king post?

Section III.

1. Sketch a queen post roof, and show how to find the scantling of the suspending pieces, when their length and the length of the tie beam are given.
2. What is the *neutral axis* of an elastic beam? Why are hollow girders now used? Explain the principle of their construction.
3. Explain the conditions of equilibrium of a geometrical staircase of stone.

Section IV.

1. Mention the ordinary tools employed by a carpenter. Sketch them, and explain their use.
2. Describe the Derrick Crane.
3. Explain the construction of a common door lock, and point out the additions and improvements which have been made in locks of the best manufacture.

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* Note.—This under the revised syllabus, in which Mechanical Physics and Experimental Physics are taken as distinct subjects, answers to Subdivision II. of Mechanical Physics.

Section V.

1. Explain the terms, *geering*, *pitch circle*. What is the proper use of the terms *axis*, *shaft*, *spindle*, *arbor*, *axle?*
2. Describe the *Geneva stop*, and explain its object.
3. How is this question solved practically?—Given the form of the teeth of one wheel, to find the form of those of another wheel, that they may work together correctly.

Section VI.

1. Describe some of the simpler contrivances for converting circular motion into alternate rectilinear motion.
2. Draw and explain Hooke's joint.
3. Describe shears for cutting iron plates or bars. Supposing the same machine used as a punching machine, and you substitute a heart-shaped cam for the eccentric, describe the difference in the motion of the punch.

Section VII.

1. In link work, find the ratio of the velocities of the two revolving pieces.
2. Describe some of the simpler contrivances for regulating the supply of steam to the cylinders of a steam-engine so as to secure uniform action.
3. Explain the mechanical contrivance by which the cutter is moved in a planing machine.

Section VIII.

1. With what class of artisans are you most likely to come in contact in your present locality?

   Select one of those classes, and say in what way you propose to assist them by scientific instruction.

SUBJECT II.—PHYSICS.

Subdivision I.—Mechanical Physics.

Examiner, The Rev. B. M. Cowie, M.A.

2nd Paper.

Section I.

1. Define *momentum*, *moving force*, *velocity*, *accelerating force*, and write down the laws of motion.

   How would you exemplify the second law?
2. Distinguish between *uniform* and *accelerated motion*. Give examples of each. Show that when no force acts the motion must be uniform.
3. In uniformly accelerated motion show that the space described varies as the square of the time.

   Be particular to mention carefully the *units* of *time*, *space*, and *velocity*.

Section II.

1. How would you explain the numerical estimate of the force of gravity?
2. Show that the length of the seconds' pendulum in the latitude of London, must be a little more than 39 inches.
3. What was *Foucault's* experiment? Describe it and show clearly the principles which it assumes and illustrates.

Section III.

1. Explain the meaning of centres of *oscillation, gyration,* and *percussion.*
2. Two heavy carriages moving on a level rail in opposite directions meet; and one of them is thrown violently *upwards.* Explain how this can be.
3. What is the form of the path of a projected body? What would it be if there were no resistance of the air? What is the amount of that resistance?

Section IV.

1. What is meant by *horse power?* What is the *unit of work?* How many horse powers will it require to lift 20,000 cubic feet of water per hour from a depth of 50 feet?
2. If the maximum speed of a locomotive engine of 60 horse power is 50 miles per hour on a level rail, what is the weight of the train? (Coefficient of friction $\frac{1}{280}$).
3. Show how to calculate the work done in drawing heavy loads up an inclined plane. Give a formula for finding the rate per hour at which an engine of given horse power will draw a given train up an inclined plane whose rise is known.

Section V.

1. What is the fundamental principle of hydrostatics?

   Shew how it is applied in the $\left\{\begin{array}{l}\text{hydrostatic}\\ \text{or hydraulic}\end{array}\right\}$ press.
2. How do you calculate the pressure on a lock gate.
3. Enunciate distinctly the laws of equilibrium of floating bodies. What is the *metacentre*?

Section VI.

1. Explain the mechanism of the moderator lamp.
2. Describe the action of the turbine.
3. What is the law connecting velocity and pressure when water is forced along a tube kept constantly full. Sketch the mode of providing towns with water on the constant pressure system? What are the best modes of regulating the house supply.

Section VII.

1. Describe a good safety valve for a steam boiler. What are the chief dangers to which steam boilers are liable?
2. Explain the action of Watt's indicator.
3. Describe the self-acting boiler feeder.

   What was the cause of the accident on board the Great Eastern.

Section VIII.

1. Describe a diving bell—with all the apparatus necessary to make a convenient machine for work under water.
2. Describe the action of the hydraulic ram.
3. Describe the Cornish engine for pumping the water from mines. Mention the usual dimensions of such engines—the modes of economising heat, and the mode in which the speed is regulated.

SUBJECT II.—PHYSICS.

Subdivision II.—Experimental Physics.

Examiner, Professor Tyndal, F.R.S.

EXPERIMENTAL PHYSICS.—1st Paper.

Section I.

1. What is the velocity of sound in air; how has it been determined; is the velocity of sound the same on high mountain ranges as at the sea level?
2. What is the velocity of light? Describe fully some one of the methods by which this velocity has been determined.
3. What is the velocity of electricity? Describe as clearly as you can the manner in which Wheatstone first determined it by the rotating mirror.

Section II.

1. The number of complete vibrations performed by a certain tuning fork in a second is 256: what is the length of the sonorous waves which it produces?
2. In what relation does the pitch of a note stand to the length, the thickness, and the tension of the string which produces it?
3. The height of a cylindrical jar, the air within which resounds to a tuning fork vibrating 256 times a second, is $12\frac{1}{2}$ inches; you are required from this to calculate the velocity of sound through air.

Section III.

1. What is the angle of incidence? What is the angle of reflection? How has their equality been proved? What is the index of refraction?
2. A lady stands before a looking glass which is exactly her own height, and sees her image from head to foot: how much of the glass is concerned in the production of this image?
3. What is meant by *total reflection?* State distinctly when it occurs. Given the index of refraction for glass, how would you find the angle at which a ray is totally reflected at the limiting surface of glass and a vacuum.

Section IV.

1. Why does a basin filled with water appear more shallow than the same basin empty? Describe how and explain why a stick is bent when thrust obliquely into water.
2. What is the principal focus of a mirror or of a lens? In the case of a concave mirror formed of a small portion of a spherical surface, where does the principal focus lie? Prove your statement if you can.
3. As regards size and position, what are the characters of an image seen in a convex mirror? An object is caused to approach a spherical concave mirror from a great distance, until at length it stands between the surface of the mirror and its principal focus: How does the image of the object move during the approach of the latter to the mirror?

Section V.

1. What is the meaning of the words "water boils" and "water freezes" which we see attached to thermometers? How many

degrees exist between the points to which these words refer on the thermometers of Fahrenheit, Celsius, and Reaumur, respectively? The lowest temperature at the top of the Finsteraarhorn last winter was 32° centigrade, what would it be if shown by Fahrenheit's thermometer?

2. State, as far as you know them, the circumstances which influence the boiling point of a liquid. At what particular point does ebullition take place? A bubble on the surface of boiling water exposed to the free air, and having a square inch of area, bears a pressure of 15lbs.; why is it not crushed?

3. You are furnished with portions of the liquids,—water, alcohol, bisulphide of carbon, and ether, and are required to determine the elasticity of their respective vapours at the temperature of your school-room: how would you proceed, and what, in general terms would be the result?

Section VI.

1. State, accurately, what is meant by the term *specific heat*, and what by the term *latent heat*.
2. The specific heat of air is 0·25, how many cubic feet of air will one cubic foot of water warm, 1 degree, by yielding up to the air a single degree of its temperature?
3. A pound of ice at 32° is mixed with a pound of water 212°, when both have reached a common temperature what will that temperature be?

Section VII.

1. State what you know regarding the transmission and reflection of radiant heat; describe the experiment on radiant heat usually made with parabolic mirrors.
2. It has been observed that snow which during the day possessed the temperature of the air above it, has during the night fallen considerably below the temperature of the air: state the condition necessary to the production of this effect. A piece of metal placed upon the snow is not thus cooled,—why?
3. Dew is never copiously formed upon a windy night. If the night be calm but cloudy it is never copious. What is the reason? State the circumstances under which it is possible for a summer night to be both calm and cloudless, and still produce but little dew.

Section VIII.

1. The air of a room containing metals, minerals, wood, linen, and woollen fabrics, has remained for a long time at a temperature of 32° Fahrenheit; it is afterwards raised to 212°, and permitted to remain for a considerable time at this temperature. How do the various substances enumerated affect the touch in both cases respectively, and what is the cause of the observed action.
2. Persons have existed in ovens the temperature of which was sufficiently high to roast eggs or to cook meat: how is it possible to expose the naked skin without harm to such a temperature?
3. Two short bars of two different metals are heated equally at one end; a bit of wax is placed at the other: one metal is a worse conductor than the other: is it possible that the wax at the end of the worst conductor may be most speedily melted? If so, state under what circumstances.

SUBJECT II.—PHYSICS.

Subdivision II.—Experimental Physics.

Examiner, Professor Tyndall, F.R.S.

EXPERIMENTAL PHYSICS.—2nd Paper.

Section I.

1. What is a loadstone? If one piece of loadstone be freely suspended, and another piece brought near to it, what are the precise effects observed?
2. How is the property of the loadstone communicated to steel? Can it be communicated to iron? Describe fully the action of two magnets upon each other.
3. In what direction does the magnetic needle point? What is the cause of its pointing in this direction? What is meant by the earth's magnetic equator? What by its magnetic poles? Define the terms declination, inclination, and intensity. How may the magnetic intensity at any point of the earth's surface be determined?

Section II.

1. State what is meant by the law of inverse square. Describe some one of the experiments by which it has been proved that the force of magnetism obeys this law.
2. A sheet of paper is placed over a horseshoe magnet, and iron filings are shaken upon it, how do the filings arrange themselves? In what condition are the filings while the magnet remains underneath? What term is used to express this condition?
3. A bar of iron is held in the direction of the dipping neecdle, what is its magnetic condition; it is reversed, what change occurs in its magnetism? it is placed east and west, what is now its state. How is its state in any one position affected by percussion?

Section III.

1. I wish to electrify a glass rod positively, and a stick of sealing wax negatively: how do I proceed in the respective cases? What is the mutual action of the two electrified glass rods, what of the two electrified sticks of sealing wax? Finally, what is the action of the glass rod upon the stick of sealing wax?
2. You are required to electrify a metal cylinder with a piece of flannel, how will you do it? State clearly the difference between the action of such a cylinder and one of glass or sealing wax.
3. Stephen Gray found that when he brought an electrified glass rod near to one end of a piece of twine several hundred feet long, the other end of the cord attracted light bodies. To secure success, however, he found it necessary to suspend his cord by loops of silk thread, and when one of these was broken and replaced by common thread, the effect ceased: why? I hand you a metallic sphere suspended by silk; you touch the metal, what takes place? You lay hold of the silk, what occurs? I ask you to tell me whether the electricity of the sphere be positive or negative, and require a practical answer; how would you proceed?

Section IV.

1. State what you understand by the term electric induction, or static induction?
2. Light bodies, say pith balls, are attracted and repelled alternately by an electrified glass rod: describe exactly the electric conditions in virtue of which such bodies are thus acted upon.
3. Over the knob of a gold-leaf electronometer is held a glass rod which has been rubbed with silk; the leaves diverge—with what electricity? You touch the knob with your fingers; what occurs? You finally remove the glass rod: describe and explain the action which follows its removal.

Section V.

1. Describe the plate electrical machine, and explain the charging of the prime conductor by electricity from the plate.
2. Describe and explain the electrophorus: how would you charge a Leyden jar from the instrument?
3. State, as far as you know, the origin of the Leyden jar; describe the jar; state accurately how it is charged, and explain its mode of action.

Section VI.

1. Describe some simple means of generating a voltaic current.
2. You are furnished with a number of plates of zinc and copper and are required to arrange them so as to form a voltaic pile: how would you proceed? What would be the electric condition of the two ends of such a pile?
3. Describe fully the battery of Daniel, of Grove, or of Bunsen; and state in what direction the current circulates in the battery which you describe when its two poles are connected by a wire.

Section VII.

1. Describe fully the analysis of water by a voltaic current.
2. Describe the chemical action which takes place in the vessel in which the zinc is immersed in Groves' battery, and also what takes place in the vessel containing the platinum.
3. The electric current is sent through a series of vessels the first of which contains a solution of common salt, the second some iodide of potassium, the third some hydrochloric acid, and the fourth some sulphate of soda in solution; describe accurately what takes place in each.

Section VIII.

1. Describe as fully as you can the action of a voltaic current upon a freely suspended magnetic needle.
2. You are furnished with a magnetic needle, and are required to ascertain whether a current is passing through a telegraphic wire at any given moment, and if so to determine the direction of the current: how would you do it?
3. Describe an accurate means of measuring the strength of a current by means of its action upon a magnetic needle.

SUBJECT III.—CHEMISTRY.

Subdivision I.—INORGANIC CHEMISTRY.

Examiner, Professor HOFMANN, Ph.D., F.R.S.

INORGANIC CHEMISTRY.

SECTION I.

1. Describe the usual processes for the preparation of oxygen gas.
2. Give an outline of the chemical processes involved in the manufacture of sulphuric acid.
3. Describe the action of sulphur upon the alkaline carbonates at a high temperature, and the deportment of the resulting products under the influence of atmospheric air.

SECTION II.

1. Give an outline of the process of combustion.
2. Describe the manufacture of carbonate of soda.
3. A salt has been found to contain in 100 parts—

17·1	Calcium.
26·5	Phosphorus.
1·7	Hydrogen.
54·7	Oxygen.
100	Salt.

What is the formula of the salt? Give the details of calculation. The following equivalents to be used:—

Calcium - - - -	- 20
Phosphorus - - -	- 31
Hydrogen - - -	- 1
Oxygen - - - -	- 8

SECTION III.

1. Describe the method of separating baryta, strontia, and lime.
2. Give the formula of ammonia, its per-centage composition, by weight and by volume.
3. Give the chemical history of the phosphoric acids, and their compounds.

SECTION IV.

1. How is magnesia separated from the alkalies?
2. What is meant by the term *hardness* when applied to water? Distinguish the different kinds of hardness in water, and describe a practical method of determining it.
3. Give a brief outline of the chemical history of chlorine and its principal compounds.

SUBJECT III.

Subdivision II.—ORGANIC CHEMISTRY.

Examiner, Professor HOFMANN, Ph.D., F.R.S.

ORGANIC CHEMISTRY.

SECTION I.

1. Describe the process for preparing cyanogen.
2. Describe the method of preparing hydrocyanic acid, and the transformation which it undergoes in the presence of acids and alkalies.

3. Give an outline of the chemical history of the ferrocyanides and ferricyanides. State their use in distinguishing the two classes of iron salts.

Section II.

1. State the formula of cane sugar and glucose (grape sugar), and give the equations representing their change during the process of fermentation.
2. Describe the successive changes which starch undergoes in its transformation, first into alcohol, and lastly into acetic acid.
3. Give a sketch of the alcohols and homologues, of the aldehydes, and of the acids corresponding to them.

Section III.

1. Describe the process of etherification.
2. Give a short sketch of the fatty bodies, and of the process of saponification.
3. Describe the relation in which alcohols, either simple or compound, and anhydrides, simple and compound, stand to water. Illustrate each of these groups by a formula.

Section IV.

1. Describe one of the processes for determining the equivalent of an organic acid.
2. Give an outline of the method of determining the vapour density of an organic body.
3. An organic base has been found to consist of—

Carbon - - -	77·42
Hydrogen - - -	7·53
Nitrogen - - -	15·05
	100·00

The platinum salt of the base contains 32·99 per cent. of platinum. What is the formula of the base? Give the details of calculation. The following equivalents to be used:—

Carbon - - -	6·0
Hydrogen - - -	1·0
Nitrogen - - -	14·0
Chlorine - - -	35·5
Platinum - - -	98·7

SUBJECT III.—CHEMISTRY.

Subdivision I.—Inorganic Chemistry.

Examiner, Professor Hofmann, Ph.D., F.R.S.

Practical Examination in Analysis. Seven hours allowed.

1. Qualitative analysis of a mixture consisting of two acids and two bases soluble in water or acids.
2. Qualitative analysis of a mixture consisting of two acids and two bases partly or entirely insoluble in water and acids.
3. Qualitative analysis of more complicated mixtures.

SUBJECT IV.—GEOLOGY AND MINERALOGY.

Subdivision I.—Geology.

Examiner, Professor A. C. Ramsay, F.R.S.

GEOLOGY.—1st Paper.

Section I.

1. What is the meaning of an *aqueous rock?*
2. How were *stratified rocks* formed?
3. How would you distinguish *marine from fresh water stratified rocks?*

Section II.

1. What is meant by *igneous rocks?*
2. Name several *varieties of igneous rocks,* and their *constituent minerals.*
3. State the manner in which *igneous rocks* of various kinds are generally *associated with stratified rocks.*

Section III.

1. What is meant by *central heat?*
2. How is the existence of central heat supposed to be proved?
3. Is there any supposed *connexion between central heat and volcanoes;* and are there any other theories respecting *the origin of volcanoes,* and if so, state the nature of one of them.

Section IV.

1. What is meant by a *fossil?*
2. How have fossils become *embedded in rocks?*
3. Write the names of the various groups of *British stratified formations,* placing the oldest at the bottom, and the newest at the top, of the column.

Section V.

1. In what districts of England and Wales do the Cambrian and Silurian rocks lie?
2. Name the *larger subdivisions* of the Cambrian and Silurian rocks, and name some characteristic Silurian orders *and genera of fossils.*
3. In what formations are the great Welsh slate quarries, and what is supposed to be *the origin of slaty cleavage?*

SUBJECT IV.—GEOLOGY AND MINERALOGY.

Subdivision I.—Geology.

Examiner, Professor A. C. Ramsay, F.R.S.

GEOLOGY.—2nd Paper.

Section I.

1. In what British formations does *workable coal* occur?
2. Name some of the chief *genera of fossils* by which you would easily distinguish *Carboniferous* from *Silurian rocks.*
3. Draw a section of an imaginary, or of an actual, *coal shaft,* and state the general nature of the alternations of its strata.

Section II.

1. What is the nature of the chief *building stones* of the English Permian rocks?
2. In what *formation* in England does *rock salt* occur, and in what manner is it associated with the strata in which it lies?
3. Of what *kinds of rocks* does the *Lias* consist? what are their chief *economic uses?* and how would you distinguish *Lias* and *Coal measures* by their *fossils?*

Section III.

1. In what parts of England do the *Oolitic, Cretaceous, and Tertiary rocks* below the drift lie?
2. State the *nature or lithological characters* and *economic uses* of the chief subdivisions of these strata.
3. In the column of *British marine strata;* name the points where there *is a complete break in the succession of life in time;* or, in other words, where *no species of fossils are common* to two successive formations.

Section IV.

1. What is meant by *disturbance of rocks?*
2. What is the *difference* between *a dyke and a lode?*
3. Draw any real or imaginary horizontal section, showing strata lying *unconformably* on other strata.

Section V.

1. What is a *fault?*
2. State any one way in which you might detect a fault at the surface.
3. Draw a real or imaginary *horizontal section*, showing under what conditions it is, or might be, advisable to sink through Permian or any Secondary strata *in search of coal.*

SUBJECT IV.—GEOLOGY AND MINERALOGY.

Subdivision II.—Mineralogy.

Examiner, Professor W. W. Smyth, M.A., F.R.S.

MINERALOGY.—1st Paper.

Section I.

1. Define the word *mineral* as employed in scientific language.
2. What is the province of mineralogy as distinguished from chemistry and from geology?
3. Describe the successive steps by which mineralogy has been brought to its present position among the sciences.

Section II.

1. State in what respects *colour* is—among the physical characters of minerals—an insecure guide.
2. What is *double refraction?* and in what mineral substances is it, observable?
3. Describe some of the chief phenomena of the *polarisation of light* and the minerals in which it is most observable.

Section III.

1. Define and give drawings of a *cube*, a *tetrahedron*, and a crystallographical *pyramid*.
2. Give examples, with drawings, of minerals crystallising in the form of an octohedron, a square prism with pyramidal terminations, and a rhombohedron.
3. Describe in detail the most convenient mode of arranging in groups the forms assumed by crystallised bodies.

Section IV.

1. Describe the physical and chemical characters of quartz.
2. Mention the distinguishing features of twelve varieties of the species quartz.
3. What are the mineral silicates, and how may they best be scientifically grouped?

Section V.

Discuss the models of crystals placed before you, stating for each to what *system* it belongs, how you would name it, by what symbol you might represent it, and what substances are known to assume that form.

SUBJECT IV.—GEOLOGY AND MINERALOGY.

Subdivision II.—Mineralogy.

Examiner, Professor W. W. Smyth, M.A., F.R.S.

MINERALOGY.—2nd Paper.

Section I.

1. Are clay, mercury, water, to be ranged among minerals? Give the arguments for and against such view.
2. Mention the principal minerals, with their *comparative hardness*, which are sufficiently hard to resist the action of a file.
3. Describe fully the *Corundum* and *Tripoli*, stating from what places they are obtained, and to what purposes they are applied.

Section II.

1. Describe the nature of the combinations in which the metals occur in the more common ores.
2. State in detail the physical and chemical characters of *copper pyrites*, *tin stone*, and *ruby silver*, giving a drawing in each case of one of the ordinary forms of crystal.
3. Describe *Galena*, its various forms, and the several minerals resulting from the changes to which this substance is naturally subjected.

Section III.

1. State under what circumstances certain metals are found in the *native* state.
2. Describe *meteoric* iron, and the peculiarities by which it is distinguished from that metal such as it is produced by art.
3. Give a full description of the species *Chrysolite*, and mention anything remarkable about it with reference to meteoric iron, and to volcanic rocks.

Section IV.

Examine the mineral specimens placed before you, naming each of the species which may happen to be associated; mention the distinctive character by which they may be recognized, and describe what is most noteworthy as to their history and application to economic purposes.

SUBJECT V.—NATURAL HISTORY.

Subdivision I.—Zoology.

Examiner, Professor T. H. Huxley, F.R.S.

ANIMAL PHYSIOLOGY AND ZOOLOGY.—1st Paper.

Section I.

1. What are the nutritive matters contained in bread, cheese, peas, rice, and meat?
2. Explain the process of digestion.
3. Suppose a piece of bread to be eaten, state what changes it undergoes in passing through the alimentary canal.

Section II.

1. What are the appearances presented by a drop of human blood when magnified 300 diameters or more.
2. Describe the structure of the heart and the course of circulation in man.
3. What are the principal forms assumed by the heart, or central circulatory organ, in the animal kingdom?

Section III.

1. Give an account of the structure and mode of action of ordinary muscle.
2. How many kinds of muscle are there in the human body, and what are their different modes of action?
3. Describe the structure of nerve-substance, and give an account of its principal properties.

Section IV.

1. Point out the correspondence of the different parts of the human eye with those of a camera obscura.
2. Describe the mechanism by which the eye is moved and its exposed surface kept clean and moist.
3. Explain in what manner the eye is adjusted to the different distances of objects seen, and why an artificial squint is accompanied with double vision. State briefly the theory of the stereoscope.

Section V.

1. How does a flesh-wound heal when its lips are kept together and air excluded, and how does a broken bone heal?
2. On what physiological grounds is it as absurd as it is mischievous to roll a half-drowned person on casks, or place him with his head downwards.
3. A reaper in a field accidentally cuts himself in the lower part of the thigh; you, a bystander, see the blood pumping in great jets from the wound; deduce from well-known physiological facts the nature of the injury and the course you ought to take to prevent the man from dying before a surgeon can reach him.

SECTION VI.

1. Define the sub-kingdoms *Mollusca, Annulosa* (or *Articulata*), and *Vertebrata.*
2. What is meant by the terms antenna, carapace, elytron, vertebra, femur, scapula?
3. By what characters can a true insect be distinguished from all other animals?

SUBJECT V.—NATURAL HISTORY.

Subdivision I.—ZOOLOGY.

Examiner, Professor T. H. HUXLEY, F.R.S.

ANIMAL PHYSIOLOGY AND ZOOLOGY.—2ND PAPER.

SECTION I.

1. Give an account of the structure and habits of the common fresh-water polype or *hydra.*
2. What is the nature of the red coral of commerce, and how does it differ from common coral?
3. Give a sketch of the structure and distribution of coral reefs, and of the mode in which they are formed.

SECTION II.

1. To what class does the earthworm belong, and why?
2. Describe the structure and mode of growth of a tapeworm (*tænia*).
3. What well-established facts render it extremely improbable that parasitic worms are ever produced by spontaneous generation?

SECTION III.

1. To what order of insects does the dragon fly belong? Give an account of the metamorphosis which it undergoes.
2. Describe the characteristic features in the organization of the honey bee (neuter) and the mode in which honey and wax are produced.
3. Give an account of the structure and natural history of the plant louse or blight insect (*aphis*).

SECTION IV.

1. To what group of *Mollusca* does the pearl oyster belong, and what are pearls and mother-of-pearl?
2. Describe the most remarkable points in the organization of the common snail.
3. What mollusks are called *Cephalopoda,* and why? Describe the organization of the suckers, of the arms, and of the jaws and ink bag in this group.

SECTION V.

1. Why is the whale no fish, in a zoological sense, and what is the nature of whalebone?
2. How do the circulatory and respiratory organs of a frog differ from those of a perch, on the one hand, and those of a bird, on the other?
3. How do the bats (*cheiroptera*) differ from ordinary mammals, on the one hand, and birds on the other.

SUBJECT V.—NATURAL HISTORY.

Subdivision II.—Botany and Vegetable Physiology.

Examiner, Dr. Lankester, M.D., F.R.S.

VEGETABLE PHYSIOLOGY.

Section I.

1. Name the principal saline compounds found in the ashes of plants. (9)
2. In what parts of the plants are cellulose, starch, fixed oils, and gluten, found? (12)
3. What are the physical and chemical properties of starch, cane and grape sugar, fixed oils, and albumen? (15)

Section II.

1. Describe the structure, functions, and uses, of the stomates in plants? (12)
2. Describe the forms assumed by the hairs of plants, and the positions they occupy; also the nature of ligneous tissue, and its uses in the arts. (16)
3. What are the principal forms of the tissues of plants pointing out the special nature of those used in the manufacture of textile fabrics? (20)

Section III.

1. What are the principal forms of the roots of plants, and the nature and functions of the parts called spongioles? (9)
2. What are the substances and their chemical composition that are absorbed by plants, and from which their various secretions are formed? (12)
3. What is the structure of the root, and the functions it performs? Is the root an organ of excretion, and what facts are urged for and against this theory? (15)

Section IV.

1. Describe the structure of a stem, and the difference between exogenous, endogenous, and acrogenous stems. (9)
2. Describe the structure of exogenous, endogenous, and compound leaves, and the nature of the function of exhalation. (12)
3. What is the histological structure of the leaf: its position on the stem, the principal forms it assumes, and the functions it performs? (15)

Section V.

1. Describe the structure of the stamens, and their prevailing numbers in the classes of plants, and give the names of the orders of plants distinguished by the peculiarities of the structure of the stamen. (9)
2. What is the structure of the pistil, and its various forms, and the arrangement of the ovules and placenta in its interior? (12)
3. What is the nature of carpellary leaves, and how are they arranged in the following fruits?—the Pome, the Hesperidium, the Legume, the Drupe, the Glans, the Pepo, the Cremocarp, the Etærio, the Silique, the Capsule, the Strobilus, the Bacca. (15)

SECTION VI.

1. Describe the structure of the embryo of endogenous and exogenous plants, and the changes the seed undergoes during germination. (12)
2. What is the nature of the function of impregnation in plants, and the history of the development of the embryo? (16)
3. What is the function of the ovules and pollen in the higher plants, and how are these organs represented in the cryptogamous plants? (20)

SUBJECT V.—NATURAL HISTORY.

Subdivision II.—BOTANY AND VEGETABLE PHYSIOLOGY.

Examiner, Dr. LANKESTER, M.D., F.R.S.

SYSTEMATIC BOTANY.

SECTION I.

1. What are the distinctions of the classes in the Linnean classification of plants? (12)
2. What are the principal distinction between Exogens, Endogens, and Acrogens? (16)
3. Give the principal distinctions between the classes Exogens, Endogens, and Acrogens; also of the groups Rhizogens, Gymnogens, Dictyogens, and Thallogens. (20)

SECTION II.

1. What are the principal forms of the fungi? (9)
2. What are the characteristic features of the group Algæ, and the useful plants belonging to the order? (12)
3. What are the characteristics of the natural order of Ferns, and the nature of their reproductive organs? (15)

SECTION III.

1. What are the characters of the order Labiatæ, and the useful plants belonging to it? (9)
2. What are the characters of the order Amentaceæ, and the useful plants belonging to the order? (12)
3. What are the characters of the natural order Compositæ: its principal divisions, and the useful plants belonging to the order? (15)

SECTION IV.

To what natural order do the plants labelled 1 to 10 belong? (*Two marks will be given for each correct answer.*) (20)

SECTION V.

1. Describe the plant labelled C. (6)
2. Describe the plant labelled B. (8)
3. Describe botanically the plant labelled A. (10)

SECTION VI.

What is the genus and species of the plants marked I. to X. (*Two marks will be given for each correct answer.*) (20)

LONDON:
Printed by GEORGE E. EYRE and WILLIAM SPOTTISWOODE,
Printers to the Queen's most Excellent Majesty.
For Her Majesty's Stationery Office.

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27.8.96